Assessment Schedule – 2014

Physics: Demonstrate understanding of mechanical systems (91524)

Assessment Criteria

Achievement	**Achievement with Merit**	**Achievement with Excellence**
Demonstrate understanding requires writing statements that typically show an awareness of how simple facets of phenomena, concepts or principles relate to a described situation. For mathematical solutions, relevant concepts will be transparent, methods will be straightforward.	*Demonstrate in-depth understanding* requires writing statements that typically give reasons why phenomena, concepts or principles relate to given situations. For mathematical solutions, the information may not be directly useable or immediately obvious.	*Demonstrate comprehensive understanding* requires writing statements that typically give reasons why phenomena, concepts or principles relate to given situations. Statements will demonstrate understanding of connections between concepts.

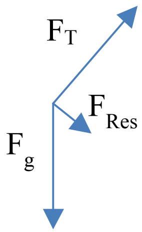
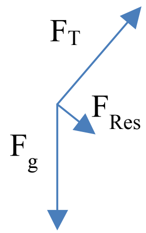
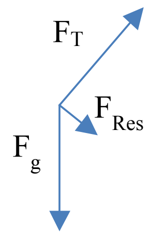
Evidence Statement

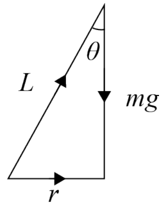
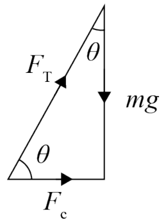
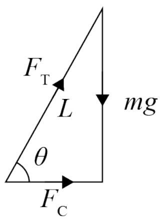
Q	Evidence	Achievement	Merit	Excellence
ONE (a)(i)	$\omega = \frac{\Delta\theta}{\Delta t}$ $T = \frac{360°}{\omega} = \frac{360°}{14.7} = 24.49$ days $= 24.49 \times 24 \times 60 \times 60 = 2.11 \times 10^6$ s	• $\frac{360}{14.7} = 24.5$ days OR Correct ω: = 1.7014×10^{-4} ° s^{-1} OR $\omega = 2.96 \times 10^{-6}$ rad s^{-1} (written with ω or with units OR $\frac{360}{14.7} \times 86\,400$ (shows subs but not equation) • Correct working showing conversion of days to seconds.	• Correct working showing conversion of days to seconds. AND Uses $\omega = \frac{\Delta\theta}{\Delta t}$ OR $T = \frac{1}{f}$ + proportional circle OR $T = \frac{360/2\pi}{\omega}$ OR Has described meaning of intermediate step, eg: 24.48 days for full rotation Or 1.7×10^{-4}° s^{-1} Or 2.96×10^{-6} rad s^{-1} Or show ratios, eg14.7 day 360 → 24.4 Or $f = 4.73 \times 10^{-8}$ Hz) *Can go backwards, but has to be clear.*	
(a)(ii)	$v = \frac{2\pi r}{T} = \frac{2 \times \pi \times 6.96 \times 10^8}{2.12 \times 10^6} = 2.066.7$ $= 2070$ m s^{-1} *(Answer: 2060 – 2070 dependent on rounding.)*	• Uses $v = \omega r$ with incorrect ω or T and correct r. OR Uses $v = \frac{2\pi r}{T}$ with incorrect T and correct r. OR Correct answer. OR Correct subs with wrong answer.	• Correct speed 2060 – 2070 m s^{-1} with some working – (subs or eqn).	

(b)	When the core of the Sun collapses, this will cause the radius of the particles in the core to rotate with a smaller radius. Angular momentum will be conserved, so if the rotational inertia decreases, the core will have to rotate at a higher angular velocity.	• Angular momentum is conserved. • Rotational inertia of core will get smaller. **OR** Angular velocity increases because mass is closer to the centre / axis. *Accept inertia in place of rotational inertia.*	• Angular momentum is conserved, therefore if rotational inertia decreases, angular velocity increases OR $L = I\omega$ therefore, if I decreases, ω increases. OR ω increases because I decreases due to mass closer to the centre / axis. *Accept inertia in place of rotational inertia.* *Radius smaller is acceptable for mass closer to the centre / axis.*	• Angular momentum is conserved AND $L = I\omega$ AND I decreases due to mass closer to the centre / axis THEREFORE ω increases. *Accept inertia in place of rotational inertia.* *radius smaller is acceptable for mass closer to the centre / axis.*
(c)	For geostationary motion, the period of the satelite has to be equal to the period of Mercury And $F_c = F_g$ $\frac{GMm}{r^2} = \frac{mv^2}{r}$ $v = \frac{2\pi r}{T}$ $r^3 = \frac{GMT^2}{4\pi^2}$ $r = \sqrt[3]{\frac{6.67\times10^{-11}\times3.30\times10^{23}\times(5.067\times10^{6})^2}{4\pi^2}}$ $r = 2.43\times10^{8}$ m	• $F_c = F_g$ **OR** $\frac{mv^2}{r} = \frac{GMm}{r^2}$ **OR** $v = \sqrt{\frac{GM}{r}}$ • $v = \frac{2\pi r}{T}$ • Period of satelite period of Mercury *MAXIMUM 2As*	Merges ($F_c = F_g$ OR $\frac{mv^2}{r} = \frac{GMm}{r^2}$) • And $v = \frac{2\pi r}{T}$, or $v = \omega r, \omega = 2\pi f$ with rearranging incorrect OR Using $F_c = F_g$ to derive $r = \frac{GM}{v^2}$ OR Full answer going backwards.	Correct rearrangement and substitution for r^3 or cube root of r AND ($F_c = F_g$ OR $\frac{mv^2}{r} = \frac{GMm}{r^2}$) AND $v = \frac{2\pi r}{T}$

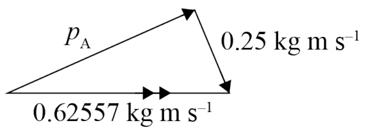
(d)	Interpreted as if Total probe: The mass that is lost will have angular momentum, so the angular momentum of the space probe will decrease. The rotational inertia of the space probe will also decrease. The effect of these two changes will be that they cancel and the angular velocity will remain constant. Interpreted as if Partial probe: Angular momentum is conserved because of no external torque, therefore angular speed stays the same. / Instrument does not apply torque to the rest of the probe ,so angular speed does not change.	• TOTAL probe: Loss of instrument means decrease in rotational inertia or angular momentum of probe OR PARTIAL probe: No torques therefore angular speed stays the same. OR MISINTERPRETATION: Idea that orbital speed is independent of mass of satellite. Has to show idea of mass cancelling from F_c or F_g or not in $v=\sqrt{\frac{GM}{r}}$	• TOTAL probe: instrument takes L away and I away, therefore angular speed stays the same. $L = I\omega$ **OR** PARTIAL probe: instrument does not apply torque to the rest of the probe so the rest of the probe does not change angular speed.	

Q1	**Not Achieved**			**Achievement**		**Achievement with Merit**		**Achievement with Excellence**	
	N0	**N1**	**N2**	**A3**	**A4**	**M5**	**M6**	**E7**	**E8**
	No response, no relevant evidence	1A	2A	3A	4A	2M + 1A	3M Or 1E + 1M	1E + 2M	2E + 1M

TWO (a)	$T = 2\pi\sqrt{\frac{l}{g}} = 2\pi\sqrt{\frac{1.55}{9.81}} = 2.50\text{ s}$ $t = \frac{1}{2}T = 1.25\text{ s}$	• Correct period.		
(b)	Tension and gravitational force add to make the restoring force towards the equilibrium.  The bob is stationary at point of release. This restoring force makes the bob speed up from as it goes towards the middle. The restoring force decreases and goes to zero as the bob goes to the middle, so the acceleration decreases to zero and the bob has constant speed at the equilibrium position. *Accept* F_{res} *horizontal*	• Gravitational and tension forces identified. • Force is towards the equilibrium position. OR Force proportional to displacement OR At equilibrium no force AND at end points maximum force. • At release point $v = 0$, and at equilibrium v is maximum. OR Speeds up / accelerates as it goes towards the centre. *MAXIMUM 2As* *Accept net /total / restoring force in place of force, but not gravitational force or tension force.*	•  OR Idea of direction of tension and gravitational force (either stating the directions or saying they don't cancel, or correct ideas of components) OR (F_{res} towards equilibrium SO that bob speeds up / accelerates. AND Restoring force decreases so acceleration decreases OR At equilibrium no F_{res} so constant speed / no acceleration.) *Accept net force /total force in place of restoring force.*	• ( OR Idea of direction of tension and gravitational force (either stating the directions or saying they don't cancel, or correct ideas of components).) AND F_{res} towards equilibrium SO that bob speeds up / accelerates. AND Restoring force decreases so acceleration decreases OR At equilibrium no F_{res}, so constant speed/no acceleration. *Accept net force /total force in place of restoring force.*

(c)(i)	  $r = 0.290$ m $L = 1.55$ m $\sin\theta = \frac{r}{L} = \frac{0.290}{1.55}$ $\Rightarrow \theta = 10.78°$ or 0.188 rad $F_g = mg$ $= 1.8 \times 9.81$ $= 17.658$ $F_t = \frac{F_g}{\cos\theta}$ $\frac{1.8 \times 9.81}{\cos 10.78} = 17.975$ N ***ALERT:*** θ $\tan^{-1}\left(\frac{0.29}{1.55}\right)$ 10.59 *is wrong answer*	• Correct angle OR Find $F_g = 17.658$ and use INCORRECT angle to find F_T	• Correct tension force showing working for correct angle. AND evidence of correct trig used. $F_T = \frac{F_g}{\cos\theta}$ AND $F_g = 17.658$ or evidence of mg used.	
(ii)	$\cos\theta = \frac{F_C}{F_T} = \frac{0.290}{1.55}$ $\Rightarrow F_C = \frac{0.290 \times 17.975}{1.55} = 3.3631$ $F_C = \frac{mv^2}{r} \Rightarrow v = \sqrt{\frac{3.3631 \times 0.290}{1.8}} = 0.7361$ $v = 0.74$ m s^{-1} 	• Obtain F_c as number or equation Eg $F_c = F_g\tan\theta$ or $F_c = F_T\sin\theta$ or $F_c = \sqrt{F_T^2 - F_g^2}$ **OR** Uses $F_c = \frac{mv^2}{r}$ to find v with wrong F. *Follow on error accepted.*	• (Evidence of use of trig or pythagorus in attempt to get F_c AND uses $F_c = \frac{mv^2}{r}$ t o find v (Eg mistakes – doesn't use sqr root, uses wrong trig or sin in pythagorus, or re-arrange incorrectly)) OR • Correct answer with insufficient working *Follow on error accepted.*	• Some working shown ($F_c = \frac{mv^2}{r}$ plus correct trig or pyth) and consistent answer and unit. *Follow on error accepted.*

Q2	Not Achieved			Achievement		Achievement with Merit		Achievement with Excellence	
	N0	**N1**	**N2**	**A3**	**A4**	**M5**	**M6**	**E7**	**E8**
	No response, no relevant evidence	1A	2A	3A	4A	2M OR 1E+2A	3M	1E + 2M	2E +1A

THREE (a)	$p_{system} = (m_A + m_B) \times v_{com} = (0.517 + 0.684) \times v_{com}$ $p_{system} = p_A + p_B = 0.517 \times 1.21 + 0 = 0.62557$ $v_{com} = \frac{1.21 \times 0.517}{0.517 + 0.6841} = 0.52087 = 0.521 \text{ m s}^{-1}$ $= 0.521 \text{ m s}^{-1}$	• $P = mv = 0.62557$ OR evidence of correct number calculated eg $\frac{5.17 \times 1.21}{0.517 + 0.684} = 0.52087$	• $p = mv$ OR $m_1v_1 + m_2v_2 = (m_1 + m_2)v_{COM}$ OR $p_{COM \text{ or } TOTAL} = p_A + p_B$ AND Substitution into equation to find correct answer.	
(b)(i)	Momentum is conserved, so the size of the change of momentum on disc A is equal to the size of the change in momentum of disc B. As B had no momentum to start with, its final momentum must be equal to the change in momentum. $\Delta p = mv \Rightarrow v = \frac{0.250}{0.684} = 0.365 \text{ m s}^{-1}$	• Momentum is conserved. OR $\Delta p_B = \Delta p_A$ (In words, or equations, or by stating $\Delta p_B = 0.250$) OR Statement of Newton 3rd law, $\Delta p = F\Delta t$ OR $p = mv$ and $\frac{0.250}{0.684} = 0.365497$	• Momentum is conserved OR $\Delta p_B = \Delta p_A$ (In words, or equations, or by stating $\Delta p_B = 0.250$) OR Statement of Newton 3rd law, $\Delta p = F\Delta t$ AND $p = mv$ and $\frac{0.250}{0.684} = 0.365497$	
(b)(ii)	$p_{system} = 0.62557 \text{ kg m s}^{-1}$ $p_{system} = p_A + p_B$  $p_A = \sqrt{0.62557^2 - 0.25^2} = 0.57344$ $= 0.573 \text{ kg m s}^{-1}$	• $p = mv$ equation used correctly for some momentum. *ONLY if no credit given for (a) or (b)(i).*	• Shows Pythagorus with momentum, wrong answer. OR Correct vector diagram with labels or numbers - diagram either Δp or total p. (Arrows not needed) wrong answer.	• Shows evidence of Pythagorus or vector diagram. AND Correct answer. *Carry on error from wrong p in 3a or 3b(i) OK.*

(c)	The only forces that will be acting on the discs will be tension force in the cord. As this is an internal force acting within the system, neither the momentum of the system nor the velocity of the centre of mass of the system will change. No friction therefore no external force acting on the system thus momentum is conserved.	• No friction / frictionless. OR No external forces. • Tension / force on string is an internal force. OR Forces due to cord oppose / cancel. *(Accept closed system in place of "no external forces".)*	• No friction, no external forces. OR No external forces because force due to string is internal. OR No external forces because string forces oppose / cancel each other. *(Accept closed system in place of "no external forces".)*	• No friction therefore no external forces therefore p is conserved AND Force of the string is internal. OR string forces oppose / cancel each other. *(Accept closed system in place of "no external forces")*

Q3	Not Achieved			Achievement		Achievement with Merit		Achievement with Excellence	
	N0	N1	N2	A3	A4	M5	M6	E7	E8
	No response, no relevant evidence	1A	2A	3A	4A	2M +1A OR 1E+2A	3M OR 1E + 1M	1E+1M +1A	2E + 1A

Cut Scores

	Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
Score range	0 – 6	7 – 13	14 – 18	19 – 24